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ORGANIZATION OF THE CONTROL-SYSTEM DESIGN

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The design of accelerator-control systems presents unusual difficulties of a non-technical type. As the accelerator produces a single output it must be controlled as a single entity. One man who has the responsibility for producing the beam must be in charge. On the other hand many sub-systems must operate together to produce the overall result and because the design of these sub-systems require the intense concentration of highly qualified technical people the design of the accelerator must be done by relatively independent sub-groups.

If a control group is established it can tend to acquire a higher status than the sub-groups because it has a wider overall responsibility. The control design must interface with all the sub-systems and at each interface agreement must be reached between the design group and the control group. If relative status becomes an issue, no matter how well hidden, the machine design, cost and schedule is sure to suffer.

On the other hand if each sub-group designs its own control system the situation can be even worse. With this organization initial construction cost can be low and time can be short. However, maintenance of the many sub-systems designed to different standards can become almost impossible and the difficulties of interconnection can considerably increase the cost and time for design and construction of more automatic and flexible overall control.

Other difficulties of control-system design exist. Control equipment is undergoing rapid development through the government support of space and military technology. There are many ways of accomplishing the same control functions, many of which are satisfactory and of comparable cost. Style plays an important part in most control design. Because of the elegance and cleverness that can be displayed in control details, designers tend to become more concerned with the techniques of the design than with utility. This emphasis on techniques is strengthened by the desire of some designers to follow techniques with which they are familiar and with which they are sure of results while others are anxious to gain experience with new techniques. Control systems should be judged by how well they control or enable the operator to control the accelerator and not by how new or interesting their components or circuits are.

Finally it must be recognized that control system design is fun. This makes everyone want to get into the act and causes unhappiness in those who are necessarily excluded in order to get anything done.

The NAL design organization is highly decentralized which makes the establishment of a general control group difficult. What is apparently needed is a compromise which combines as much as possible of the value of standardization without loss of the enthusiasm and technical concentration encouraged by the relatively autonomous sub-system groups.

Control design can be divided into (1) "housekeeping" design functions, (2) the design of control circuits and devices and (3) the design of the central control station.

The "housekeeping" design functions are concerned with wiring, wireway and termination standards and standards applying to the interfaces between the trunk wiring and the individual sub-systems. Standardization of wiring device and material specifications, terminology and numbering and drawing practice is necessary for installation and maintenance by the electrical crews.

The housekeeping design work should be done early in the project because the wiring installation will probably take much time. Small differences in procedures and standards can make large differences in installation and maintenance man hours. Fortunately experience exists at the other large accelerators which should make it possible to establish economical standards.

The portion of the work here called "housekeeping" is concerned with the hardware used to carry information around the accelerator and is not concerned with the information transmitted. The type of information transmitted and the properties of the wiring provided must of course be consistent. This part of control design is not usually considered fun and so can be done reasonably rapidly by a small group.

One of the steps in the wiring design is to determine how many of what kinds of wires (or channels) must be provided. This will have to be obtained in part from the control requirements of the sub-system designers. Control standards cannot be forced on the sub-system designers but the latter should be required to justify any special types of channels or equipment they require as these variations will cost more than the standard and increase installation and maintenance difficulties. An inventory of the information transmission requirements of the sub-groups appears to be one of the earliest

pieces of business in the general control system design.

No matter how the inter-system wiring is designed it must be possible to make changes or additions at any time. This usually means the use of wire trays and spare terminal space. A large fraction of the wiring should be installed at one time to keep the installation cost down. The decision as to how much wiring will be needed at start-up based on the incomplete state of the control design when the wiring supplies must be ordered is a difficult decision to make.

The second area of control design, the design of circuits and devices can be reasonably assigned to the sub-group responsible for the controlled device. Although wiring and drawing standards should be uniform complete freedom should be allowed in circuit design and component selection. The designers should be responsible for the performance of a sub-system which includes its control. The fact that the sub-system controls may follow different philosophies based on the designer's choices should give little difficulty because each sub-system is specialized anyway.

In the third area, that of the central control station, personal preferences can have a predominating effect. This is an architectural problem in the sense that esthetics and function are inextricably combined. One approach, which has only the advantage of organizational simplicity, is to assign each sub-group its own rack space and let them design their own controls. At the other extreme can be a completely integrated console which could conceivably have one cathode ray screen, one knob and a piano-type keyboard. The operator could call up anything he wanted to do or see by playing the proper keys.

The central controls are probably the least urgent of the three control design areas. The machine can actually be run from local controls and a haywire central control station can be rigged up in an emergency. One plan could be to do just that and leave the final design until after operating experience is obtained.

One control device that applies to the accelerator as a whole is what can be called the "time and function generator". This is the device which controls the timing of the various machines as the beam is passed from one to another and determines the rate of energy increase in each machine. This device is, of course, of vital importance but, at least in its simpler versions, is not difficult to design. It should be quite easy to build in the laboratory shops so that its design need not be frozen until quite late in the construction period. At the time of start-up complete timing flexibility to the limits of the accelerators should be available but automatic features such as the ability to store and recall programs will not be necessary for initial operations.

APPENDIX

Accelerator control requirements naturally differ from those of other fields, power plants, oil refineries, computers, and aircraft for example. Superficially it may appear that all the control techniques of all of these fields might be applicable to accelerators but this is far from the case. Many of the control problems of other fields do not exist for accelerators. The following are the general characteristics of accelerator controls.

The quantities controlled and displayed are usually electrical (compare an airplane or space probe where the output is primarily mechanical).

Response time of the controlled equipment is short compared to the time required to take action. (Compare an oil refinery where the time response is measured in hours or a gun pointing where it is in milliseconds).

No great hazard exists in the operator responding too slowly. (Compare an airplane or ship).

In the NAL accelerator the longest transmission distances are several miles. (Compare the NASA world wide control network and the control circuit of a bench instrument).

It is possible and practical for one operator to run the entire machine when there is no trouble. (Compare the control crews used by NASA). Trouble is common, however, and a major use of control and display is in trouble shooting. Down time is expensive.

Terminology in the control field is confusing and this confusion leads to errors in thinking and misunderstandings in discussions. The word "control" is applied here as the name of the system which causes or inhibits the useful output of another system or device. Another common use of the word is the knob by which the operator varies some physical (electrical or mechanical quantity).

Included under the general term is the means and function of returning information to an operator or a record. If the information is mainly static and only departures from normal are shown this is usually called "monitoring". The word "display" is coming into use not so much for the type of information but for the method of making it visually apparent. No general term for any sort of information given to the operator for any reason seems to exist.

The word "computer" is used to cover a broad range of devices and systems. The current interest in and glamour of computers encourages manufacturers to apply the word to as many products as possible. The general public probably understands it to mean large-scale digital computers. However, anything that handles information and which has some internal standard or decision -- making ability can reasonably be, and usually is, called a computer. Thus a voltage regulator has the elements of a computer and can be called one even though it existed long before the "computer age".